5/33-90

309613

N91-14233

CO Mapping of the Nuclear Region of NGC6946 and IC342 with the Nobeyama Millimeter Array

SUMIO ISHIZUKI[1,2], RYOHEI KAWABE[1], SACHIKO K. OKUMURA[1], KOH-ICHIRO MORITA[1], AND MASATO ISHIGURO[1]

[1] Nobeyama Radio Observatory, National Astronomical Observatory

[2] Department of Astronomy, University of Tokyo

INTRODUCTION

CO observations of nearby galaxies with nuclear active star forming regions (and starburst galaxies) with angular resolutions around 7" have revealed that molecular bars with a length of a few kiloparsecs have been formed in the central regions of the galaxies[1-4]. The molecular bar is interpreted as part of shock waves induced by an oval or barred potential field. By shock dissipation or dissipative cloud-cloud collisions, the molecular gas gains an infall motion and the nuclear star formation activity is fueled. But the distribution and kinematics of the molecular gas in the nuclear regions, which are sites of active star formation, remain unknown. Higher angular resolutions are needed to investigate the gas in the nuclear regions. We have made aperture synthesis observations[5,6] of the nuclear region of the late-type spiral galaxies NGC6946 and IC342 with resolutions of $7''.6 \times 4''.2$ (P. A. = 147°) and $2''.4 \times 2''.3$ (P. A. = 149°), respectively. The distances to NGC6496 and IC342 are assumed to be 5.5 *Mpc* and 3.9 *Mpc*, respectively. We have found 100–300 *pc* nuclear gas disk and ring inside a few *kpc* molecular gas bars. We present the results of the observations and propose a possible mechanism of active star formation in the nuclear region.

OBSERVATIONS

The observations were made using the Nobeyama Millimeter Array (NMA), which consists of five antennas with a diameter of 10 meters. All antennas are equipped with SIS receivers with system noise temperatures (SSB) around 600 *K* at the zenith. A Fourier transform digital spectro-correlator FX was used. 10 baselines and 40 baselines are used for the mapping of NGC6946 and IC342, respectively. The field of view is 65" in diameter, which corresponds to 1.7 *kpc* and 1.2 *kpc* at the distance of NGC6946 and IC342, respectively.

RESULTS

NGC6946[5]: 300 pc Nuclear Molecular Gas Disk and Molecular Gas Bar

Figure 1a shows a map of CO integrated intensity. The galaxy has a strong nuclear concentration of molecular gas with a size of 300 *pc* and a diffuse feature with north–south extension of ~ 1.5 *kpc*. The diffuse feature is seen more clearly in a map of CO intensity integrated over a velocity range, $V_{LSR} = 21.4$–$99.5\ kms^{-1}$ (Fig. 1*b*). It shows a bar-like morphology generated at the reading sides. This <u>*bar – like structure*</u> is interpreted as part of shock waves or a density wave pattern in an oval potential field. A map of CO velocity field (Fig. 1*c*) indicates that the nuclear concentration is circularly rotating, i.e., <u>*a nuclear molecular disk*</u>, and that the gas in the bar-like structure has an infall motion. If we assume the conversion equation between molecular hydrogen mass and CO flux density,

$M(H_2) = 9000 \times (I_{CO}/Jy\ kms^{-1}) \times D_{Mpc}{}^2\ M_\odot$, D_{Mpc} is the distance to the galaxy, the gas mass in the nuclear molecular disk is estimated to be $3\times10^8\ M_\odot$. This means that about 10 % of the total molecular gas in the whole galaxy is concentrated to the central 300 *pc* region and 26 % of the dynamical mass inside a radius of 150 *pc* is in the form of H_2 molecule. The mass of molecular gas in the field of view ($\sim$ 1.7 *kpc*) is $4\times10^8\ M_\odot$. A bright HII region with a size of 200 *pc*[7] and a radio continuum source[8] are found at the nuclear region. The nuclear molecular disk is a site of active star formation.

Ic342[6]*: 100 pc Nuclear Molecular Gas Ring and Molecular Gas Ridges*

Figure 2a shows a map of CO integrated intensity. We have found *a molecular ring* with a diameter of 110 *pc* and two narrow ridges, each of which has a size of $\lesssim$80 *pc* $\times$ 500 *pc*. The map of CO velocity field (Fig. 2*d*) shows that the gas in the molecular ring is circularly rotating and that the gas in the ridges has an infall motion along the ridges. The mass of the molecular gas in the field of view is estimated to be $1.7 \times 10^8\ M_\odot$. The molecular ring has a H_2 mass of $0.4 \times 10^8\ M_\odot$. Figures 2*b* and 2*c* show VLA radio continuum maps at 2 *cm* and 6 *cm*[8], respectively. At 2 *cm* and 6 *cm*, about 100 % and 50 % of the emission is thermal origin, respectively. The flux density of radio continuum emission corresponds to the number flux density of UV photons from 3.5×10^4 B3–O4 stars[8]. The molecular gas ring just fits to the 6 *cm* continuum ring. This suggests that active star formation occurs in the nuclear molecular gas ring. The *ridges* are shifted to the leading side. They are also interpreted as molecular gas in shocks in the oval potential.

DISCUSSION

Here we propose a possible scenario of nuclear active star formation. An oval potential field with a few *kpc* scale produces shock waves which cause loss of angular momentum of gas and as a result the gas infalls toward the nuclear region. The infall motion of the gas slows down at the inner a few hundred *pc* region because the oval distortion of the gravitational potential becomes very small. Owing to the efficient gas supply in the oval potential and the slowing down of gas infall, a nuclear gas disk (or a ring) which has a few hundred *pc* size and a mass of a few $10^8\ M_\odot$ is formed. In this massive nuclear disk, frequent cloud-cloud collisions probably occur and induce active, massive star formation.

REFERENCES

1) Lo, K. Y. *et al.* 1984, *Ap. J. (Letters)*, **282**, L59.
2) Ball, R *et al.* 1985, *Ap. J. (Letters)*, **298**, L21.
3) Canzian, B., Mundy, L. G. and Scoville N. Z. 1988, *Ap. J.*, **333**, 157.
4) Ishiguro, M. *et al.* 1989, *Ap. J.*, in press.
5) Ishizuki, S. *et al.* 1989, submitted to *Ap. J.*
6) Ishizuki, S. *et al.* 1989, in preparation.
7) Bonnarel, F., Boulesteix, J. and Marcelin, M. 1984, *Astr. Ap. Suppl.*, **66**, 149.
8) Turner, J. L. and Ho. P. T. P. 1983, *Ap. J. (Letters)*, **268**, L79.

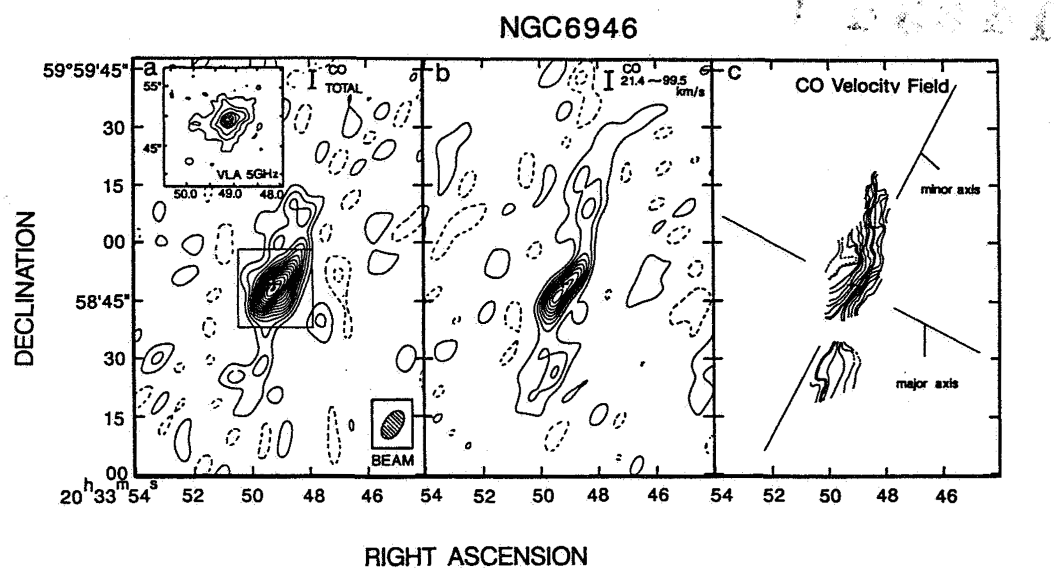

Figure 1 — *NGC6946* — (10" corresponds to 270 *pc*.) (*a*) A map of the total CO integrated intensity. An inset shows a map of the λ 6*cm* radio continuum emission[8]. A cross indicates its peak position. (*b*) A map of the integrated intensity in the velocity range $V_{LSR} = 21.4 - 99.5 kms^{-1}$. (*c*) A contour map of the CO weighted mean velocity. Dashed and solid curves indicate $V_{LSR} = -20, -10, 0, 10, \ldots, 120 kms^{-1}$ from east to west. A thick solid curve indicates the systemic velocity, $V_{LSR} = 60 kms^{-1}$.

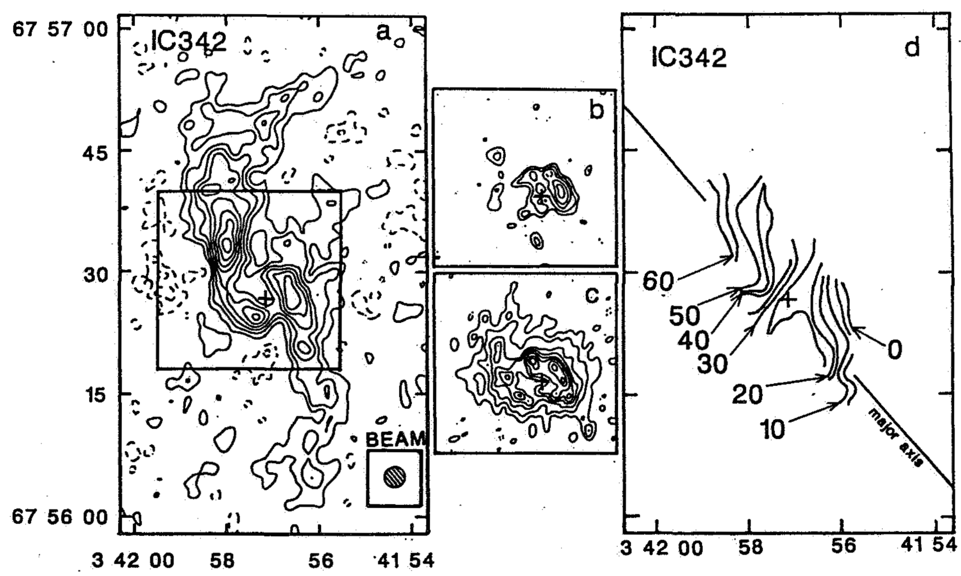

Figure 2 — *IC342* — (5" corresponds to 95 *pc*.) (*a*) A map of the total CO integrated intensity. A cross indicates the peak of 2.2μm emission. (*b,c*) Maps of the λ 2*cm* and λ 6*cm* radio continuum emissions[8], respectively. The size of the frames is the same as that of a box shown in Fig. 2a. (*d*) A contour map of the CO weighted mean velocity. The numbers indicates LSR velocities, V_{LSR}, in unit of kms^{-1}.